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AN ANALYSIS ON THE EFFECTS OF THE AIRCRAFT SERVICE PERIOD ADJUSTMENT (ASPA) PROGRAM ON THE DIRECT COSTS OF STANDARD DEPOT LEVEL MAINTENANCE (SDLM) FOR THE F-14A

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Almost every year of ASPA, the average direct labor and material costs of F-14A SDLM have increased, rising from $763,571 in 1985 to a high of $1.68 million in 1993. However, this analysis shows that only a weak correlation exists between the number of months an aircraft spends in tour and the direct costs of SDLM. A multiple regression model including additional variables such as aircraft age, tour number, whether a modification was performed concurrently, and work standard was found to explain 57 percent of the variation in the direct costs of SDLM. The effect of time in tour was insignificant

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Almost every year of ASPA, the average direct labor and material costs of F-14A SDLM have increased, rising from $763,571 in 1985 to a high of $1.68 million in 1993. However, this analysis shows that only a weak correlation exists between the number of months an aircraft spends in tour and the direct costs of SDLM. A multiple regression model including additional variables such as aircraft age, tour number, whether a modification was performed concurrently, and work standard was found to explain 57 percent of the variation in the direct costs of SDLM. The effect of time in tour was insignificant.

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I. INTRODUCTION

A. GENERAL

In the current era of shrinking budgets, one of the premier challenges for the Navy has been to identify resources for fleet modernization. One of the best potential sources for these funds is reduction in the operating and support costs of naval units. Therefore, much attention is being focused on the life-cycle costs of weapons systems. In the world of Naval Aviation, Standard Depot Level Maintenance (SDLM) accounts for a significant portion of an aircraft's life-cycle costs.

The purpose of SDLM is to correct corrosion and structural problems that cannot be fixed at the organizational or intermediate levels of maintenance. Aircraft are inducted into SDLM at the end of their Operating Service Period (OSP). The OSP is based on a determination, through use of reliability centered maintenance, of how long the aircraft can be operated safely without undergoing periodic depot-level maintenance. The OSP defines the minimum period between SDLMs and provides the basis for planning, programming, and budgeting this element of aircraft inventory management.

In 1991, the average cost of a Standard Depot Level Maintenance (SDLM) overhaul for the F-14 Tomcat was $1.87 million per aircraft. The standard work package involved 154 structural inspections and 104 system performance checks. By 1993, the average cost of a SDLM had risen to $2.65 million per aircraft. In 1994, the work package was significantly reduced to just 83 structural inspections and 39 systems

performance checks, only 47% of the work requirements previously completed. Interestingly enough, despite the marked decrease in work performed, the average cost per aircraft rose to $3.24 million by the end of 1994. (Washington, 1996)

With statistics such as these, it is no wonder that there is concern regarding what is driving the costs of overhauling aircraft to rise so dramatically. A popular belief is that the adoption of the Aircraft Service Period Adjustment (ASPA) program in 1984 is the reason for the increases (Ramsey & Legidakes, 1994, Washington, 1996).

The ASPA Program was designed to determine whether there is a need to induct an aircraft into SDLM. Previously, an aircraft was inducted for SDLM at the end of its OSP which for the F-14 is 56 months. The ASPA evaluation is an assessment of the overall general material condition of an aircraft conducted by the depot responsible for the type of airplane. The purpose of an ASPA inspection is to determine if the aircraft can be deferred from SDLM induction and remain in service for an additional 12 months. ASPA recognizes that all aircraft do not deteriorate at the same rate. Deterioration, expressed as the state of aircraft material condition, is a consequence of environment, number of carrier landings, catapult launches, operation cycles, and the quality of routine maintenance. The ASPA program basically changes the basis for SDLM induction from "on-time" to "on-condition."

Over time, Navy officials questioned whether the intended consequences of ASPA-- particularly the reduction in the number of SDLMs -- were being outweighed by difficulties in budgeting for future SDLM events and by increases in the amount of maintenance performed when aircraft finally were inducted (Levy 2, 1993).

Supporters of the ASPA program argue that the program allows the Navy to save depot money annually by preventing unnecessary induction into SDLM. On the other hand, it has been argued that the proliferation of ASPA extensions has lead to an overall deterioration of the material condition of aircraft by the time they are inducted into SDLM. The degraded condition has in turn resulted in more extensive work being required than planned for or budgeted. This is believed to drive the observed increased costs for SDLM, which in turn have resulted in fewer aircraft being inducted into SDLM.

B. METHOD OF RESEARCH

The purpose of this thesis is to investigate whether there is a correlation between the rising costs of F-14 SDLMs and the ASPA program. Through use of linear and multiple regression models, it will examine the correlation between direct material and direct labor costs and the amount of time an aircraft serves "in tour." While the standard OSP for the F-14A is 56 months, as a result of the ASPA program, some aircraft have served up to 104 months before being inducted into SDLM. This thesis will also examine whether there is any correlation between costs and other factors, such as age and number of flight hours, which could drive up the cost of SDLM.

C. SUMMARY OF FINDINGS

The linear regression analysis shows a weak correlation between time spent in tour and the direct costs of SDLM. However, time in tour was found to be statistically insignificant in the multiple regression model. After identifying 11 potential variables that

may have affected the direct costs of SDLM, the only four explanatory variables which were statistically significant were aircraft age, whether a modification was performed concurrently, estimated labor hours to complete SDLM, and tour number.

Multiple ASPA deferrals for F-14As are not the norm. Fifty-two percent of all aircraft that fail ASPA do so during the first inspection. Less than 23 percent of the aircraft that fail ASPA do so after the second inspection.

The results of this analysis show that the increase in time that aircraft serve in tour due to the ASPA program does not cause the cost of SDLM to increase.

D. THESIS ORGANIZATION

Chapter II will provide background information regarding the Navy's aviation maintenance structure, the ASPA program and work performed during SDLM.

Chapter III will describe the methodology employed for gathering data and performing the analysis.

Chapter IV will present the findings of the analysis.

Chapter V will contain conclusions and recommendations.

II. DESCRIPTIONS OF ASPA AND SDLM

A. INTRODUCTION

This chapter begins with a discussion of the Navy's aviation maintenance structure. It will also describe ASPA and the role it plays with regards to SDLM and the management of SDLM.

B. AVIATION MAINTENANCE STRUCTURE

The Navy's aviation maintenance structure is designed around three levels of effort, organizational being the lowest, followed by intermediate and depot. The Navy's approach is to repair aeronautical equipment and material at the lowest practical maintenance level. The program protects weapons systems from the inherently corrosive environment in which they operate through an active corrosion control program, and it promotes a systematic preventive maintenance schedule.

1. Organizational Maintenance

Organizational maintenance, also referred to as "O-level" maintenance, is performed by an operational unit to keep assigned aircraft in a full mission-capable status, while continually improving the local maintenance process. Maintenance at this level includes scheduled maintenance, such as daily, preflight, postflight, conditional, and phase aircraft inspections, all of which are considered preventive in nature. Conditional inspections are unscheduled events which are required whenever an aircraft hits a specific

over-limit condition, such as a hard landing. The phase maintenance concept divides the total scheduled maintenance requirement for an aircraft into small phases of approximately the same work content. Completion of all the required phases at their specified intervals completes the phase inspection cycle. (OPNAVINST 4790)

O-level maintenance also includes the unscheduled removal and replacement of components by using squadron test equipment and hand tools in an effort to keep aircraft in a full mission-capable status. Unscheduled maintenance hours are required to fix systems and subsystems in the aircraft due to failures or indications of likely future failure. (Stoll, 1993)

2. Intermediate Maintenance

Intermediate maintenance, also referred to as “I-level,” is the responsibility of and is performed by designated maintenance activities in support of using organizations (OPNAVINST 4790.2F). I-level support consists of equipment material support both on and off the aircraft, such as scheduled and unscheduled maintenance of components removed at the organization level. This work includes related support equipment; manufacture of some aeronautical components, liquids and gases; calibration of O-level maintenance equipment; and technical assistance to O-level maintenance personnel.

3. Depot Maintenance

Depot maintenance, “D-level,” is performed between operational service periods, utilizing special structural inspections, to ensure the continued flying integrity of airframes and flight systems. Depots provide rework of aviation parts, systems and

components and related support equipment. D-level maintenance includes manufacturing items and component parts, making modifications, testing, inspecting, sampling, and reclamation. Depots provide support services to the other levels, including professional engineering, technology, and calibration services. The depots support the organizational and intermediate level activities by providing technical assistance and carrying out those functions which are beyond the responsibility or capability of the O or I level activities, through the use of the depots' more extensive facilities, skills and materials. Depot level services can be carried out in depots or in the field by personnel representing the depots. (OPNAVINST 4790.2F)

C. THE AIRCRAFT SERVICE PERIOD ADJUSTMENT PROGRAM

Each Type/Model/Series (t/m/s) of aircraft in the Navy has a normal tour length defined by its Operating Service Period (OSP), which represents the standard cycle for aircraft to be inducted into SDLM. A tour length is the elapsed calendar time from the end of an aircraft's last SDLM until its induction for its next one. "The OSP for a t/m/s is determined through the application of Reliability Centered Maintenance (RCM) and sustained with age exploration" (NAVAIR 4730.10A). Through 1983, it was Navy policy to induct aircraft into aviation depots for major overhauls at the end of their OSPs.

In 1984, the Navy implemented the Aircraft Service Period Adjustment (ASPA) program. "The ASPA philosophy is that depot level maintenance will be the result of a deliberate action by an inspection team that has actually stood the aircraft at "parade rest" rather than having maintenance occur as the result of the calendar" (Johannsen, 1985).

The ASPA evaluation cycle begins near the end of an aircraft's OSP, specifically the aircraft's period end date (PED), which is the year and month the aircraft reaches the end of its OSP. Recognizing that the material condition of all aircraft does not deteriorate at the same pace, the objective of the ASPA evaluation is to determine if the aircraft can remain in service through a 12-month PED adjustment. The effect of the ASPA program has been to change the basis for SDLM induction from "on-time" to "on-condition." This change has also resulted in more depot-level maintenance actions being processed in the field (NAVAIR 4730.10A).

The ASPA evaluations are conducted by a qualified depot level industrial Planner and Estimator (P & E) team, utilizing approved Local Engineering Specification (LES). An ASPA evaluation consists of a maintenance documentation review and a physical examination of the aircraft. The inspection looks for leading indicators of corrosion or other structural problems. The ASPA is not designed to produce a list of discrepancies that, if corrected, would allow the aircraft to remain in tour another year.

D. STANDARD DEPOT LEVEL MAINTENANCE

Aircraft are inducted into the depots for SDLM at the end of their OSP for correction of corrosion and structural problems that cannot be fixed at the organizational or intermediate levels of maintenance. During SDLM, an aircraft receives an extensive tear down and evaluation to estimate the expected work to be completed.

Each aircraft type has a SDLM specification work package which identifies a number of conditional (non-destructive) inspections to be performed on critical fatigue

areas. The required inspections are determined on the basis of systematic analysis of the airframe, systems and component design, operational performance and reliability and maintenance data. Although the rework accomplished during SDLM cannot make the aircraft new again, it's purpose is to recover the material condition so the aircraft can go back for another tour in the fleet (Levy 1, 1991).

Several components require mandatory maintenance performed on them at the end of the aircraft tour length. Since 1994, the F-14A SDLM specifications included 83 structural inspections and 39 system performance checks (Washington, 1996). As a result of these conditional inspections, over 413 components are also removed and either remanufactured or replaced. Thus, roughly 63% of the aircraft's 650 components are repaired or replaced during SDLM. The specifications are currently being rewritten and will include an additional 24 system performance checks associated with the landing gear which had been previously eliminated from the work package (Roberts, 1997).

This thesis will focus on the two primary variable inputs that are used to rework aircraft airframes, labor man-hours and cost of materials. Although there are also some overhead and general and administrative costs that support the work being done, they are generally fixed costs and will not be addressed in the analysis.

There are several reasons for which an F-14A can be inducted into SDLM. The most common is failing to be deferred following an ASPA inspection. The second reason is that the aircraft hits a Time Compliance Requirement (TCR). In the case of the F-14A, an aircraft will undergo a TCR modification when it reaches 5000 flight hours. An aircraft will also be inducted for a TCR modification if it is approaching its fatigue life

expended (FLE) threshold. Fatigue life expended is a function of operational tempo and includes numbers of catapult shots, landings and flight hours. The F-14A FLE threshold is 82% of its total calculated fatigue life. If an aircraft is approaching the 5000 hour mark or FLE of 82% and is currently operating under an ASPA extension, it may be inducted into the depot for the modification and SDLM concurrently.

During SDLM, it is estimated that 75% of all man-hours expended occur during the disassembly, reassembly and test of the aircraft. Less than 25% of all man-hours go towards correcting all categories of discrepancies. (Roberts, 1997). Currently, the average time to complete a SDLM on an F-14A is 363 days (Alexander,1996).

The materials cost varies from one overhaul to the other. Presently, whenever a component needs to be replaced, it is reworked concurrently. Rarely is a new one bought commercially. This practice, however, is in the process of changing. A new initiative is coming on line in which 150 items which were previously reworked concurrently will be purchased through the Navy supply system. If the net cost, price plus surcharge, of an item is less than the cost of rework, then the item is purchased. Although materials costs may rise somewhat, the overall cost of SDLM is expected to decrease through a 15% decrease in turn around time (TAT). Currently, approximately $1.8 million is spent on reworking parts during SDLM. An estimated $600,000 is expected to be saved through this new initiative. (Roberts, 1997)

The first F-14 requiring SDLM was inducted into the Navy Aviation Depot (NADEP), Norfolk in 1975. The SDLM effort became dual-sited in 1982, when NADEP North Island commenced overhauls on F-14s. In 1991 the decision was made to single-

site the SDLMs in Norfolk. NADEP North Island completed its last F-14 overhaul in April 1992. In 1993 the Base Realignment and Closure Committee (BRAC) decided to close NADEP Norfolk. As a result, F-14 SDLMs are conducted primarily at NADEP Jacksonville, which inducted its first Tomcat in October, 1994. (Washington, 1996) To date, 10 of 25 aircraft inducted have been delivered from NADEP Jacksonville.

Until 1995, F-14s had been overhauled exclusively at Navy depots. In the fall of 1995, the first of five aircraft was inducted for SDLM at Grumman in St. Augustine, Texas and only 1 has been completed to date. For purposes of this analysis, only those SDLMs conducted at NADEPs will be included.

The multiple sources of F-14 overhauls may have contributed to the variability in the costs of SDLM. In addition, the frequent changes of SDLM sites may have prevented the realization of savings associated with the "learning curve" effect. Both of these issues will be addressed in Chapter III.

E. ASPA DEFERRAL RATES

As mentioned earlier, the ASPA program basically changes the basis of SDLM induction from "on-time" to "on-condition." Since 1985, deferral rates for the F-14 have ranged from 72% to 86%. Table 1 contains the deferral rates from 1985 to 1996.[1]

[1] All deferral and failure rates were calculated from the F-14 ASPA historical database maintained by Naval Air Systems Command Industrial Capabilities Department in Patuxent River, MD.

Table 1. ASPA deferral rates for F-14A

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Deferral Rate	72	73	53	78	73	73	80	78	75	86	76	76
No. of Aircraft Inspected	36	44	32	49	63	70	64	37	53	88	92	42

These deferrals would seem to indicate that aircraft serve longer periods between SDLMs. Table 2 shows the deferral rate by inspection number and tour number. The first ASPA inspection (ASPA 1) occurs at the end of the aircraft's OSP. The "ASPA 2" column represents the number of aircraft that have been deferred for one 12 month period. Most aircraft which are deferred for two times or more are in their first tour.

Table 2. Deferral rate by ASPA inspection number and tour number

	ASPA 1	ASPA 2	ASPA 3	ASPA 4	ASPA 5
Tour 1	92	88	66	82	33
No. aircraft inspected	100	78	35	11	9
Tour 2	72	71	44	67	0
No. aircraft inspected	82	34	16	6	2
Tour 3	74	82	68	50	N/A
No. aircraft inspected	114	66	22	4	0
Tour 4	76	55	100	N/A	N/A
No. aircraft inspected	33	11	3	0	0
Tour 5	100	N/A	N/A	N/A	N/A
No. aircraft inspected	1	0	0	0	0

This table illustrates that the greater the tour number, the fewer number of extensions the aircraft can expect to have. This is to be expected since the aircraft continues to age through successive tours.

Although the high deferral rates may lead one to believe that aircraft undergo multiple deferrals prior to induction, not all aircraft that pass one inspection are inspected for an additional deferral. For example, only 66 percent of the aircraft that passed their first inspection were inspected for a second deferral. As mentioned earlier in this chapter, some aircraft that are deferred are still inducted into the depot for TCR modifications and SDLM would be performed concurrently. Table 3 shows the deferral rate by ASPA inspection number. The deferral rates are high for aircraft undergoing their first and second inspection, but the number of aircraft inspected and the deferral rate is lower for

Table 3. ASPA deferral rates by inspection number

Inspection Number	1	2	3	4	5
Number of aircraft deferred	291	153	48	15	3
Number of Aircraft Inspected	370	191	76	21	11
Deferral Rate	79	80	63	71	27

subsequent inspections. An important observation is that of the 370 aircraft ever inspected for ASPA deferrals, less than 42 percent have passed a second inspection and less than 13 percent have passed a third.

Table 4 contains the percentage of ASPA inspection failures by inspection number. This table shows that of the 154 ASPA failures, 52 percent occurred during the first inspection. The failure rate by ASPA inspection number shows that only 23 percent

of the aircraft that are inducted into SDLM, because of failing an ASPA inspection, served two or more additional 12 month periods.

Table 4. ASPA inspection failures

ASPA Inspection	ASPA 1	ASPA 2	ASPA 3	ASPA 4	ASPA 5
Percent of total failures	52	21	18	4	5
Number of failures	80	32	28	6	8

This table indicates that less than 50 percent of all aircraft which are inducted into SDLM for failing ASPA spend additional time in tour prior to failing ASPA. This implies that longer tour lengths aren't as prevalent as previously believed.

Although the average time in tour may not be increasing greatly, there has been a marked increase in the direct labor and materials costs of the average SDLM. Table 5 shows the changes in direct labor hours and direct materials costs for aircraft inducted into SDLM from 1985 to 1995. All costs were converted to fiscal year 1996 dollars for

Table 5. Average SDLM direct labor and materials costs

Year	Average Labor Costs	Average Materials Costs
1985	$469,237	$294,334
1986	424,130	359,637
1987	346,181	260,909
1988	360,956	404,514
1989	532,596	448,946
1990	518,650	614,840
1991	616,840	625,050
1992	605,700	682,981
1993	642,477	1,038,903
1994	669,673	898,550
1995	700,455	616,131

comparison purposes.

In 1987 there was a drop in direct labor costs due to the introduction of competition into the F-14 SDLM process. As a potential cost saving measure, NADEPs Norfolk and North Island let private contractors bid on SDLM work for specified aircraft. This resulted in major changes in the actual repair work and accounting procedures so that costs would remain low. (Levy, 1, 1991) The effect of this competition was short-lived, for by 1989 the costs had started rising again. The decrease in total costs from 1993 to 1994 reflects the reduction in SDLM specifications that occurred during this timeframe.

Table 6 contains the average direct labor and material costs according to the number of ASPA deferrals aircraft received prior to SDLM induction. The table shows that the average direct costs increase with the number of deferrals an aircraft receives

Table 6. Average direct costs of SDLM based upon number of deferrals

Number of Deferrals	0	1	2	3
Average Direct Labor Costs	$484,103	$497,498	$637,572	$453,263
Average Direct Material Costs	564,211	576,856	755,762	767,996
Average Total Direct Costs	1,048,315	1,074,354	1,393,334	1,221,260
Number of Aircraft	59	43	23	4

prior to SDLM. The difference in costs are not very significant between no deferrals and one deferral. However, there is a marked increase from one deferral to two or more deferrals. This indicates that there is some increase in the direct costs of SDLM for aircraft that spend additional time in service due to ASPA deferrals.

III. DATA COLLECTION AND MODEL DEVELOPMENT

A. INTRODUCTION

This chapter will discuss the methodology used to develop the models necessary to study the correlation between the number of ASPA deferrals that an aircraft receives and the costs incurred during SDLM.

B. DATA COLLECTION

1. Production Performance Reports

The source for obtaining labor man-hours and materials costs for each SDLM included in this study was the Production Performance Reports (PPRs) which each depot sends to Naval Air Systems Command (NAVAIR), Aircraft Division (formerly known as Naval Aviation Depot Operations Center), at Naval Air Station, Patuxent River, Maryland. The depots use the PPRs to document the work performed during SDLM. Information contained in the PPR includes the aircraft's bureau number, induction year, physical completion date, depot completing the work, actual days at the depot, estimated labor hours required based on SDLM specifications, total actual hours expended on the aircraft, direct labor costs and direct materials costs. In addition, subprogram codes are listed.

Subprogram codes are used to identify the type of work completed during a specific rework action. For example, a subprogram code of 36 indicates a SDLM without major modifications, whereas a code 38 indicates a SDLM with modifications.

Theoretically, there should be little difference in the number of hours expended between the two types of subprograms, because the hours used for the modifications are charged to another subprogram code (41 or 43). (Levy 1, 1991) However, there are known difficulties in assigning costs to the appropriate account. This will be addressed in Chapter IV.

The work standard refers to the estimated number of hours required to complete the overhaul based upon the SDLM specification. Beginning in 1993, shortly after NADEP Norfolk was placed on the Base Realignment and Closure (BRAC) list, maintenance of the work standards was less than optimal, as technicians became focused on preparing to move operations to NADEP Jacksonville. Although the values may be understated, the work standards still provided the best estimate available for comparison and were included in this analysis.

There have also been problems with dual recording in the PPR. Duplicate records and incomplete records were deleted prior to performing calculations for this thesis.

2. ASPA Inspection Database for F-14As

The ASPA historical database, maintained by the Industrial Capabilities Department of NAVAIR, also in Patuxent River, MD, was used to determine what tour an aircraft was in and how many deferrals it had received prior to being inducted to SDLM. A tour minus one represents how many times an aircraft has been through SDLM. For example, an aircraft on its first tour (tour one) hasn't been through SDLM. An aircraft on its second tour has been through one SDLM, third tour-two SDLMs, and so on.

As noted earlier, the most common reason for an aircraft to be inducted into SDLM is failure to receive an ASPA deferral. In addition, aircraft requiring a Time Compliance Requirement (TCR) modification can be inducted without having failed an ASPA inspection. The data used in the analysis contained aircraft inducted into SDLM due to failing ASPA inspections as well as requiring TCR modifications. In addition, some aircraft were inducted without failing ASPA or requiring TCR modifications, but because of operational requirements.

Although the ASPA program officially came on line in 1984, data regarding the results of ASPA inspections was not centrally maintained until 1988. As a result, few records exist regarding the results of ASPA inspections between 1984 and 1988. Of the 460 records of SDLMs which were conducted since 1984, data regarding what tour number and how many ASPA deferrals an aircraft had received prior to induction was available for only 129 of the SDLM events. An attempt was made to obtain that information from other sources, but it was unsuccessful. As a result, the population used in the statistical analysis described in Chapter IV consists of those 129 records which were verifiable. Of those 129 SDLMs, 44 of the aircraft were inducted without having failed an ASPA inspection. The data compiled from the PPRs and ASPA inspection database which was used for the linear regression analysis were compiled into a spreadsheet which is presented in Appendix A. The entire ASPA database was used to determine the deferral rates contained in Chapter II and the failure statistics contained in Chapter IV.

3. Aviation Maintenance Material Management (3M) Data

The Aviation 3M Data Collection System was used to collect information regarding other potential explanatory variables for use in constructing multiple regression models. The following information was collected for a sample of 81 aircraft:

- aircraft age, which is the time in months from acceptance into the Navy to the SDLM date
- number of flight hours for the 24 months prior to SDLM
- number of ship flight hours for 24 months before SDLM
- total number of flight hours since previous SDLM
- total unscheduled maintenance man-hours per flight hour for 24 months prior to SDLM

4. Price Indexes

In order to remove the effects of inflation, price indexes were obtained to normalize the data by displaying all costs in fiscal year 1996 constant dollars. Direct materials costs were normalized using Annual Price Change (APC) rates obtained from Navy Supply. Materials prices in the Navy Supply system are known to vary greatly from year to year, and these rates help capture that fluctuation. Direct labor costs were normalized using the Operation & Maintenance Civilian Pay Raise index which is published by the Navy's Office of Budget (FMB). A list of both indexes is contained in Appendix B.

C. MODEL DEVELOPMENT

To analyze the correlation between number of ASPA deferrals and the cost of SDLM, several linear and multiple regression models were developed. To perform the necessary regression analysis, the MINITAB Statistical Analysis package was used.

1. Linear Regression

The value of the linear regression model is that it demonstrates the relationship between two variables, such as costs and time in tour. Linear regression models were constructed using direct labor costs, direct materials costs and total direct costs as the dependent variables. It is important to look at the total because it is possible for a repair effort to be performed and accounted for in two different ways. For example, if a specific part requires replacement, it is possible for that part to be either reworked in a back shop at the depot or purchased through the supply system. In the first case, that would cause an increase in labor costs; the second case would mean an increase in materials costs. Using the total of direct costs neutralizes this effect. At the same time, it is important to see how both labor and materials costs are affected separately. Each of the dependent variables was regressed against the months in tour. As mentioned earlier, the standard tour length is 56 months, each ASPA deferral extends that period for an additional 12 months.

2. Multiple Regression

Three multiple regression models were constructed, also using direct labor costs, direct materials costs and total direct costs as the dependent variables. In addition to the number of months in tour, additional explanatory variables were added in an effort to

enhance the model and explain the observed variation in the costs of SDLM. A total of 11 potential explanatory variables were identified. These variables were selected based upon their potential to affect the cost of SDLM. The explanatory variables used were:

- Time in tour, expressed in months
- Aircraft age, expressed in months
- Result of latest ASPA inspection (fail or pass)
- Tour number
- Depot where SDLM took place
- Modification, if one was performed concurrently with the SDLM
- Work standard, estimate of labor hours required for SDLM
- Total flight hours since last SDLM
- Flight hours for 24 months prior to SDLM
- Ship flight hours for 24 months prior to SDLM
- Total unscheduled maintenance man-hours per flight hour since last SDLM

Age of aircraft was selected because it is important to know to what extent age causes additional SDLM costs. Whether or not an aircraft failed an ASPA inspection prior to induction could also affect the costs of SDLM. It is logical to think that those aircraft which fail an inspection are in worse material condition than those that don't, therefore driving up costs due to increased workload. Failure was represented in the

model using a categorical variable. A value of one was used to indicate that an aircraft failed ASPA and zero was used to indicate that it didn't fail.

What tour an aircraft is in may affect the costs of SDLM. As mentioned before, the tour number is one greater than the number of SDLMs an aircraft had previously undergone. Higher tour numbers mean more SDLMs over the aircraft's life, which in turn could mean lower SDLM costs because the aircraft is seen more frequently. Tours were represented using categorical variables.

The depot where the SDLM took place was selected to capture the inherent differences between NADEPs Norfolk and North Island. Such differences include accounting procedures and skill level of depot workers. Depots were represented using a categorical variable. Norfolk was represented with a value of one and North Island was represented with a value of zero.

Work standards generally vary from year to year in conjunction with the changes in SDLM specifications. Work standard is an estimate of the labor hours needed to complete a SDLM. As such, work standards could be expected to impact the cost of SDLM.

Information regarding flight hours was included to see what extent flying from both on and off aircraft carriers affects the cost of SDLM. Unlike the Air Force's premier fighter, the F-15, which is land-based, the F-14 operates in an extremely harsh environment on board ship.

Unscheduled maintenance man-hours per flight hour (UMMHpFH) was selected as an explanatory variable in that a higher rate of these hours could indicate a more degraded

level of material condition, therefore affecting the level of work to be performed and ultimately costs.

IV. ANALYSIS OF RESULTS

A. INTRODUCTION

This chapter will discuss the correlation between the different costs within a SDLM and the number of months that an aircraft is in tour prior to being inducted into SDLM, with the understanding that repeated ASPA deferrals lead to increases in the tour length of an aircraft. The chapter will begin with an overview of statistical terms pertinent to understanding the regression analysis performed. Finally, the results of the linear and multiple regression models will be discussed in detail.

B. STATISTICAL TERMINOLOGY USED IN REGRESSION ANALYSIS

When analyzing the results obtained from a regression analysis, there are three statistical values which are of great interest to the statistician or manager for determining the validity of a regression model. The first of these values is the t-ratio for the coefficient of the explanatory variable. A high t-ratio indicates that the explanatory variable (also referred to as the independent variable) is important in explaining the value of the dependent variable. For an independent variable to be statistically significant at the 95 percent confidence level, its t-ratio must be higher than the critical value, which is generally around two.

The second statistical value of importance is the F-ratio. The F-ratio is a measure of how well the selected set of explanatory variables model the system. If the F-ratio of a regression model is less than the critical value (approximately four at a 95 percent

confidence level), then the chosen set of explanatory variables do not correctly model the system.

The most significant use of the F-ratio in regression analysis is to check the statistical significance of the third value of importance, the coefficient of determination, or R-squared as it is commonly called. The R-squared value measures the percentage of the variability in the dependent variable that can be explained by the regression line (Liao, 1996). Values for R-squared range from zero to 100 percent. R-squared values close to zero indicate a weak relationship between the explanatory and dependent variables; values close to 100 indicate a strong correlation. As mentioned previously, the statistical significance of the R-squared value is measured by the F-ratio.

C. ANALYSIS OF RESULTS

1. Linear Regression Models

Table 7 contains the results of the linear regressions performed using the time in tour alone to explain the variation in the direct labor and materials costs and their total.

Table 7. Results of linear regression using time in tour as the explanatory variable

Dependent variable	a	b	t-ratio, a	t-ratio, b	F-ratio	R-squared
Direct labor costs	301,084	3,589	3.63	2.89	8.33	6.1%
Direct materials costs	195,554	6,436	1.08	2.38	5.66	4.2%
Total direct costs	496,638	10,025	2.00	2.69	7.5	5.4%

The value in the "a" column represents the constant term in the regression equation. The "b" value represents the coefficient of the dependent variable in the equation. As

mentioned earlier, the t-ratio, F-ratio and R-squared values indicate the statistical significance of the models.

In the equation using direct labor costs as the dependent variable, the "t-ratio b" is statistically significant at the 95 percent confidence level and therefore signifies that the explanatory variable, time in tour, plays a role in explaining the direct labor costs. The corresponding R-squared, however, shows that time in tour only explains about 6.1 percent of the total variation in direct labor costs. Therefore, the results indicate that there is a weak correlation between time in tour and direct labor costs of SDLM.

Like the regression equation for direct labor costs, the results of the linear regression models for direct materials costs and total direct costs, which are also statistically significant, indicate that there is little correlation between an aircraft's time in tour and the costs of its SDLM.

2. Multiple Regression Models

Three multiple regression models were constructed using direct labor costs, direct material costs and total direct costs as the dependent variables. Initially, a model was constructed for each using the 11 potential explanatory variables that were previously identified. However, only four of the variables were found to be statistically significant. The results of these initial models are presented in Appendix C. The variables found to be statistically significant were aircraft age, whether a modification was performed concurrently, tour number and work standard. These variables were significant for all three models, but time in tour was not.

a. Direct Labor Costs

Table 8 contains the results of the final regression equation for direct labor costs. The t-ratios indicate that each of the variables are important in explaining the variation in direct labor costs.

Table 8. Results of regression equation for direct labor costs

Explanatory Variable	Coefficient	t-ratio
Constant	-549449	-3.12
Age	2826	4.77
Modification	-87518	-3.35
Work Standard	35.18	5.02
Tour 1	288628	4.43
Tour 2	148931	3.49
R-squared = 46.2%	F-ratio = 12.86	

Although this model is statistically significant, the R-squared value indicates that it only explains 46.2% of the variation in direct labor costs. It is not surprising that aircraft age is statistically significant. It is intuitive that, as an aircraft ages, the cost of maintaining and repairing it will increase.

One interesting observation is the "modification" variable. The sign of the coefficient for the modification variable indicates that those aircraft which have modifications installed concurrently experience lower direct labor costs. A potential explanation for this is that overhaul efforts are being charged to the modification account. As mentioned in Chapter II, modifications are funded separately from SDLMs. SDLMs

are funded with Operating and Maintenance dollars, while modifications are paid for with Procurement dollars.

Another interesting observation in this model is the value of the coefficients for the tour variables. As mentioned in Chapter III, the tour number was represented using "dummy" variables. Each category, in this case tour number, was treated as a separate variable. When constructing an equation for categorical variables, the number of dummy variables used is one less than the number of categories in the data. The dummy variables created reflected whether the aircraft was on first tour, second tour, or third or fourth tour. The third and fourth tour were grouped together because of the low number of observations of aircraft in a fourth tour.

Aircraft in a first tour were coded "1,0" where the first value corresponds with the "Tour 1" variable, second value with the "Tour 2" variable. Aircraft in their second tour were coded "0,1" and those in their third or fourth tour were coded "0,0."

The values for the coefficients of the "Tour" variables indicate that direct labor costs for aircraft are greatest for aircraft in their first tour, followed by aircraft in their second tour. This is possibly due to the fact that most aircraft which serve multiple 12 month deferrals prior to SDLM induction do so in their first or second tour.

b. Direct materials costs

The results of the regression model for direct material costs are similar to those of direct labor. The statistics for the direct material costs are contained in Table 9.

Like the direct labor model, direct material costs increase with aircraft age and work standard and decrease in successive tours. Also like the labor model, direct materials

Table 9. Results of regression equation for direct materials costs

Explanatory Variable	Coefficient	t-ratio
Constant	-1464458	-3.78
Age	5616	4.30
Modification	-288908	-5.03
Work Standard	71	4.59
Tour 1	435060	3.04
Tour 2	322200	3.43
R-squared = 50.7%	F-ratio = 15.44	

costs are lower if a modification is performed concurrent with SDLM. The R-squared value indicates that this model explains 50.7% of the variation in direct materials costs.

c. Total Direct Costs

As mentioned in Chapter III, it is important to look at a model for total direct costs to offset the two different approaches which can be taken to fix a component. One approach is to rework the component and the other is to buy a new component. The first method affects labor costs and the second affects material costs. The results of the total direct costs model is displayed in Table 10. The higher value for R-squared indicates that this model was able to capture some of the variation in total costs due to the different approaches to fixing components. It also indicates that this model is slightly better for predicting the total cost of SDLM than the other two models alone.

Table 10. Results of regression equation for total direct costs

Explanatory Variable	Coefficient	t-ratio
Constant	-2013907	-4.07
Age	8443	5.07
Modification	-376426	-5.14
Work Standard	106.03	5.38
Tour 1	723689	3.96
Tour 2	471131	3.93
R-squared = 55.2%	F-ratio = 18.47	

d. Comparison between Direct Labor Costs and Direct Material Costs

Each coefficient (also called parameter) value represents the change in the dependent variable (either direct labor or material costs) for a one-unit change in the corresponding explanatory variable. To compare the effects of the different explanatory variables, the percentage change in the dependent variable was calculated by dividing the parameter value obtained from the regression by the mean value of the dependent variable. (Levy, 1, 1991) Table 11 illustrates these results for direct labor and material costs.

Table 11. Estimated effects on direct labor and material costs (percent)

Predictor	Labor	Materials
Constant	-0.9405	-2.03
Age	0.00484	0.00778
Modification	-0.1498	-0.4005
Work standard	6E-05	9.8E-05
Tour 1	0.49403	0.60307
Tour 2	0.25492	0.44663

The results show that the effects of each of the explanatory variables are stronger for direct material costs than direct labor costs. The results also show that tour number had the strongest effect on costs relative to the other variables. Modifications had the second strongest effect.

V. CONCLUSIONS AND RECOMMENDATION

A. CONCLUSIONS

This thesis has described the history of the ASPA program, ASPA deferral rates and SDLM costs for the F-14A. The analysis focused on the relationship between SDLM costs and the time an aircraft served in tour. In addition, the analysis explored the relationship between the direct labor and material costs of SDLM and other factors which may cause costs to increase. The following can be concluded:

1. Although the average direct costs of F-14A SDLMs increased with the number of deferrals, results of the regression analysis show that the correlation between time in tour and SDLM costs is weak. The combination of aircraft characteristics represented by the explanatory variables in the multiple regression model better explain the cost variation than simply focusing on a single measure such as the number of ASPA inspections.

2. Aircraft age, whether a modification was performed concurrently, work standard and tour number help explain the variation in the direct costs of SDLM. However, only 57.5 percent of the variation in the total directs costs of SDLM can be explained by these variables.

3. More than two ASPA deferrals prior to induction to SDLM is not the norm. Most aircraft that fail ASPA do so on their first inspection. Less than 13 percent of the 510 aircraft extensions granted were for third, fourth or fifth extensions.

4. It is extremely difficult to predict the costs for completing a SDLM with any accuracy. There is great variation in the estimated hours required to perform SDLM (represented by the work standard) and the actual number of hours it takes to complete it. This is reflected in the complexity of the regression model created.

B. RECOMMENDATION

Although this thesis determined that the extended time in tour due to ASPA was not driving the cost of SDLM to rise, that is not to say that other features of the ASPA program don't contribute to the variation in the costs of SDLM. As mentioned earlier, one of the effects of the ASPA program is that it interferes with the ability of the Navy to plan, program and budget for SDLM events. It is in this light that the ASPA program should be reviewed to determine whether it is in the best interest of the Navy.

C. FURTHER RESEARCH

This thesis attempted to identify those variables which explain the variation in the direct labor and material costs for F-14A SDLMs. The variables used in this analysis captured only 57.5 percent of the total variation in costs. It would be useful for prediction purposes to identify additional variables to create a model that captures more of the variation. Such a model would also help in understanding the impact of different variables on the SDLM process in terms of cost.

APPENDIX A

DATA COMPILED FROM PPR AND ASPA DATABASE

BUNO	IY	TOUR	ASPA	FAILED ASPA	DEPOT	SUB	DLC	DMC
159013	85	3	1	YES	B	38	276727	320810
159018	85	3	1	YES	C	38	473401	404038
159438	85	3	1	YES	B	38	274911	371085
159449	85	3	1	YES	B	38	281885	414470
161139	85	1	1	YES	B	38	246920	380466
161158	85	1	1	YES	B	38	255756	331095
161160	85	1	1	YES	B	38	272767	330531
158991	86	3	1	YES	C	38	385596	353312
159002	86	3	1	YES	C	38	371185	267448
159425	86	3	1	YES	B	38	322623	386767
159429	86	3	1	YES	B	38	341775	510004
159845	86	2	2	YES	C	38	339784	366778
160379	86	4	2	YES	B	38	295577	387226
160397	86	2	1	YES	B	38	309806	305097
160409	86	2	1	YES	B	38	286241	390428
161145	86	1	2	YES	B	38	276383	319307
161161	86	1	2	YES	B	38	288181	387851
161271	86	1	2	YES	C	38	329959	297056
159004	87	3	1	YES	B	38	236206	211479
159015	87	3	2	YES	B	38	266567	221449
159016	87	3	1	YES	B	38	228174	282647
159023	87	3	1	YES	B	38	264481	241985
159423	87	3	1	YES	B	38	229889	220426
159424	87	3	2	YES	C	38	255982	175724
159444	87	3	1	YES	B	38	263096	223606
159825	87	2	2	YES	C	38	296298	201313
160391	87	2	2	YES	B	38	269740	308764
160404	87	2	1	YES	B	38	248588	233624
160664	87	2	1	YES	C	38	230281	208465
160668	87	2	1	YES	C	38	321983	323346
161274	87	1	3	YES	C	38	249712	239563
161296	87	1	1	YES	C	38	247494	251053
161299	87	1	2	YES	C	38	268290	532501
161443	87	1	1	YES	C	38	244438	186992
159597	88	3	1	YES	B	38	292744	668044
159856	88	2	1	YES	C	38	258931	222167
160657	88	2	1	YES	C	38	279671	325112
160690	88	2	1	YES	C	38	380512	566093
160896	88	2	1	YES	B	38	252337	322180
160917	88	2	1	YES	B	38	291619	357016
160919	88	2	1	YES	B	38	313326	302467

BUNO	IY	TOUR	ASPA	FAILED ASPA	DEPOT	SUB	DLC	DMC
161297	88	1	2	YES	C	38	342542	362400
161298	88	1	2	YES	C	38	284672	303447
161292	89	1	3	YES	C	38	525472	142533
158623	90	3	3	NO	C	38	523750	488757
158978	90	3	4	YES	C	38	405739	429162
158999	90	3	3	YES	C	38	439754	368803
159025	90	4	1	YES	C	38	423025	430384
159454	90	4	1	YES	B	36	494530	604315
159457	90	3	1	YES	B	36	432025	439952
159606	90	3	1	YES	B	36	518799	639533
159828	90	3	1	NO	C	38	380987	488212
159849	90	3	1	YES	C	38	597752	840702
160681	90	2	1	YES	C	38	475277	361895
160693	90	2	1	NO	B	38	525005	486572
161147	90	2	1	YES	B	36	383462	325671
161150	90	2	1	YES	B	36	355539	332760
161164	90	2	1	YES	B	36	358414	421740
161276	90	2	1	YES	B	38	589966	796746
161281	90	2	1	YES	B	36	402954	509074
161598	90	1	2	NO	C	38	377112	461884
161616	90	1	1	NO	C	38	498853	428537
161850	90	1	2	NO	B	36	413661	355653
161853	90	1	3	YES	B	36	312656	399229
161857	90	1	2	NO	B	36	398832	341123
161859	90	1	2	NO	B	36	571223	561667
161861	90	1	2	YES	B	36	448117	428933
161869	90	1	2	YES	B	38	327543	245331
159868	91	3	2	YES	B	38	730776	420843
160390	91	3	1	YES	B	36	532524	464568
160403	91	3	1	YES	B	36	703916	1087946
160411	91	3	1	YES	B	36	538866	645358
160679	91	3	1	YES	C	38	620481	586656
161271	91	2	1	YES	B	38	561860	533020
161284	91	2	2	YES	B	36	545045	826597
161612	91	1	2	NO	C	38	623178	692877
161619	91	1	3	NO	B	38	549940	400547
161622	91	1	2	NO	B	38	646201	551294
161626	91	1	2	NO	B	38	583352	532163
161855	91	1	2	NO	B	36	507994	474388
161858	91	1	2	NO	B	36	493962	610794
161860	91	1	2	NO	B	36	502466	681834
161862	91	1	2	NO	B	38	515551	509992

BUNO	IY	TOUR	ASPA	FAILED ASPA	DEPOT	SUB	DLC	DMC
161864	91	1	2	YES	B	38	493314	524303
162591	91	1	1	YES	C	38	546952	523531
162705	91	1	2	YES	B	38	469756	389837
160382	92	3	3	YES	B	36	615330	550492
160407	92	3	2	YES	B	36	624167	590394
161134	92	3	1	NO	B	36	564437	1299196
161139	92	2	1	NO	B	36	639311	813168
161152	92	2	2	YES	B	36	732444	1130224
161285	92	2	3	YES	B	36	679316	689093
161603	92	1	3	YES	B	36	632441	614948
161607	92	1	3	NO	B	36	491725	602702
161609	92	1	3	YES	B	36	600735	506284
161615	92	1	3	YES	B	36	627858	747968
161618	92	1	3	NO	B	36	555658	654046
161621	92	1	3	YES	B	36	604480	843760
162590	92	1	2	YES	B	38	558569	391161
162594	92	1	2	NO	B	36	553132	595334
162597	92	1	2	NO	B	36	596717	567114
162599	92	1	2	YES	B	36	530483	434861
162602	92	1	2	NO	B	36	588595	576028
162603	92	1	2	NO	B	36	474947	365524
162692	92	1	3	YES	B	36	537312	566071
162693	92	1	3	YES	B	36	543933	453443
158629	93	3	1	YES	B	36	778933	1214726
158637	93	3	1	YES	B	36	759990	1508618
159867	93	3	1	YES	B	36	704717	1367451
160915	93	3	2	YES	B	36	723641	1484585
160926	93	3	1	YES	B	36	715507	975458
161160	93	2	1	NO	B	36	581769	1590225
161282	93	2	3	YES	B	36	656956	1332893
161620	93	1	3	YES	B	36	933969	1439847
162592	93	1	2	NO	B	36	619980	828010
162598	93	1	2	NO	B	36	566510	787851
162606	93	1	2	NO	B	36	539828	756446
162688	93	1	4	YES	B	36	601955	1041853
162696	93	1	2	NO	B	36	582748	765181
162699	93	1	4	YES	B	36	508539	876770
162704	93	1	4	YES	B	36	564989	1331978
159845	94	3	2	YES	B	36	742067	1159941
160669	94	3	3	YES	B	36	718139	1161319
160902	94	2	3	YES	B	36	645456	1595340
160925	94	2	3	YES	B	36	876834	1091743

BUNO	IY	TOUR	ASPA	FAILED ASPA	DEPOT	SUB	DLC	DMC
161141	94	3	1	YES	B	36	710655	692752
161162	94	2	4	YES	B	36	119309	143234
161274	94	2	1	YES	B	36	759219	922174
161617	94	1	3	NO	B	36	697076	716770
162689	94	1	5	YES	B	36	609165	1067307

BUNO - Aircraft Bureau Number
IY - Fiscal year inducted into SDLM
Tour - Tour number when inducted into SDLM
ASPA - Most recent ASPA inspection prior to induction to SDLM
FAILED ASPA - Whether or not the aircraft failed ASPA prior to SDLM
DEPOT - NADEP where SDLM performed
 B - Norfolk
 C- North Island
SUB - Subprogram code
 36 - SDLM no modifications
 38- SDLM with modifications
DLC - Direct Labor Costs
DMC - Direct Material Costs

APPENDIX B

PRICE INDEXES

The Department of Navy Inflation/Escalation Annual Rates
Civilian Annual Pay Raise

FY 86	3.3%[2]
FY 87	2.7%
FY 88	3.0%
FY 89	4.2%
FY 90	4.0%
FY 91	3.4%
FY 92	2.6%
FY 93	2.4%
FY 94	2.0%
FY 95	2.0%
FY 96	2.1%

Navy Supply Annual Price Change Rates

FY 86	-11.8%
FY 87	-0.5%
FY 88	-6.5%
FY 89	-13.3%
FY 90	-2.0%
FY 91	14.9%
FY 92	1.2%
FY 93	10.4%
FY 94	6.1%
FY 95	22.1%
FY 96	-22.5%

[2] FY 86 data was unavailable so an average of the succeeding three years was used to approximate the value.

APPENDIX C

MULTIPLE REGRESSION EQUATIONS USING 11 EXPLANATORY VARIABLES

1. Regression Analysis for Direct Labor Costs

The regression equation is
Direct Labor Costs = - 592060 - 35419 Failed + 1038 TIME IN TOUR
- 3645 Norfolk - 94450 Modification + 35.8 Work Standard
+ 242489 TOUR_1 + 145461 TOUR_2 + 2831 Age - 1.9 FltHours
- 9.2 Flight Hours -24 + 104 Ship Flight Hours -24 - 0.60 UMMHpFH

Predictor	Coef	StDev	t-ratio	P
Constant	-592060	230685	-2.57	0.012
Failed	-35419	40260	-0.88	0.382*
TIME IN	1038	1642	0.63	0.529*
Norfolk	-3645	49322	-0.07	0.941*
Modification	-94450	34412	-2.74	0.008
Work Standard	35.807	7.835	4.57	0.000
TOUR_1	242489	88208	2.75	0.008
TOUR_2	145461	47721	3.05	0.003
Age	2831.1	700.6	4.04	0.000
TotFltHours	-1.86	32.25	-0.06	0.954*
Flight Hours-24	-9.15	98.86	-0.09	0.927*
Ship Flight Hours	104.1	110.5	0.94	0.350*
UMMHpFH	-0.600	3.657	-0.16	0.870*

S = 113439 R-Sq = 47.7% R-Sq(adj) = 38.5% F -ratio = 5.18

Coef - Coefficient of explanatory variable
StDev - Standard deviation for explanatory variable
P - Probability of error for saying the t-ratio is significant
* - indicates that corresponding t-ratio insignificant at 95% confidence level

2. Regression Analysis for Direct Materials Costs

The regression equation is
Direct Material Costs = - 1222738 - 102978 Failed + 500 TIME IN TOUR
- 65713 Norfolk - 312629 Modification + 67.0 Work Standard
+ 318815 TOUR_1 + 301546 TOUR_2 + 5037 Age + 8.7 TotFltHours
- 180 Flight Hours -24 + 93 Ship Flight Hours -24 + 7.15 UMMHpFH

Predictor	Coef	StDev	t-ratio	P
Constant	-1222738	500330	-2.44	0.017
Failed	-102978	87319	-1.18	0.242
TIME IN	500	3560	0.14	0.889
Norfolk	-65713	106974	-0.61	0.541
Modification	-312629	74636	-4.19	0.000
Work Standard	67.04	16.99	3.95	0.000
TOUR_1	318815	191312	1.67	0.100
TOUR_2	301546	103501	2.91	0.005
Age	5037	1519	3.31	0.001
TotFltHours	8.65	69.95	0.12	0.902
Flight Hours-24	-179.6	214.4	-0.84	0.405
Ship Flight Hours	92.6	239.7	0.39	0.701
UMMHpFH	7.149	7.931	0.90	0.371

S = 246037   R-Sq = 53.5%   R-Sq(adj) = 45.3%   F - ratio = 6.53

3. **Regression Analysis for Total Direct Costs**

The regression equation is
Total Direct Costs = - 1814798 - 138397 Failed + 1538 TIME IN TOUR
- 69358 Norfolk - 407079 Modification + 103 Work Standard
+ 561303 TOUR_1 + 447007 TOUR_2 + 7868 Age + 6.8 TotFltHours
- 189 Flight Hours -24 + 197 Ship Flight Hours -24 + 6.5 UMMHpFH

Predictor	Coef	StDev	t-ratio	P
Constant	-1814798	640620	-2.83	0.006
Failed	-138397	111803	-1.24	0.220
TIME IN	1538	4559	0.34	0.737
Norfolk	-69358	136969	-0.51	0.614
Modification	-407079	95564	-4.26	0.000
Work Standard	102.85	21.76	4.73	0.000
TOUR_1	561303	244955	2.29	0.025
TOUR_2	447007	132522	3.37	0.001
Age	7868	1946	4.04	0.000
Tot FltHours	6.80	89.56	0.08	0.940
Flight Hours-24	-188.8	274.5	-0.69	0.494
Ship Flight Hours	196.7	307.0	0.64	0.524
UMMHpFH	6.55	10.15	0.64	0.521

S = 315024 R-Sq = 57.5% R-Sq(adj) = 50.0% F-ratio = 7.66

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